The Shiraz model

A tool for incorporating anthropogenic effects and fish–habitat relationships in conservation planning

Mark Scheuerell

National Marine Fisheries Service
Seattle, WA

Acknowledgments

Ray Hilborn (UW)
Mary Ruckelshaus (NMFS)
Krista Bartz (NMFS)
Kerry Lagueux (NMFS)
James Battin (NMFS)
Hiroo Imaki (NMFS)
Andy Haas (Snohomish Co.)
Kit Rawson (Tulalip Tribe)
Curt Kraemer (WDFW)

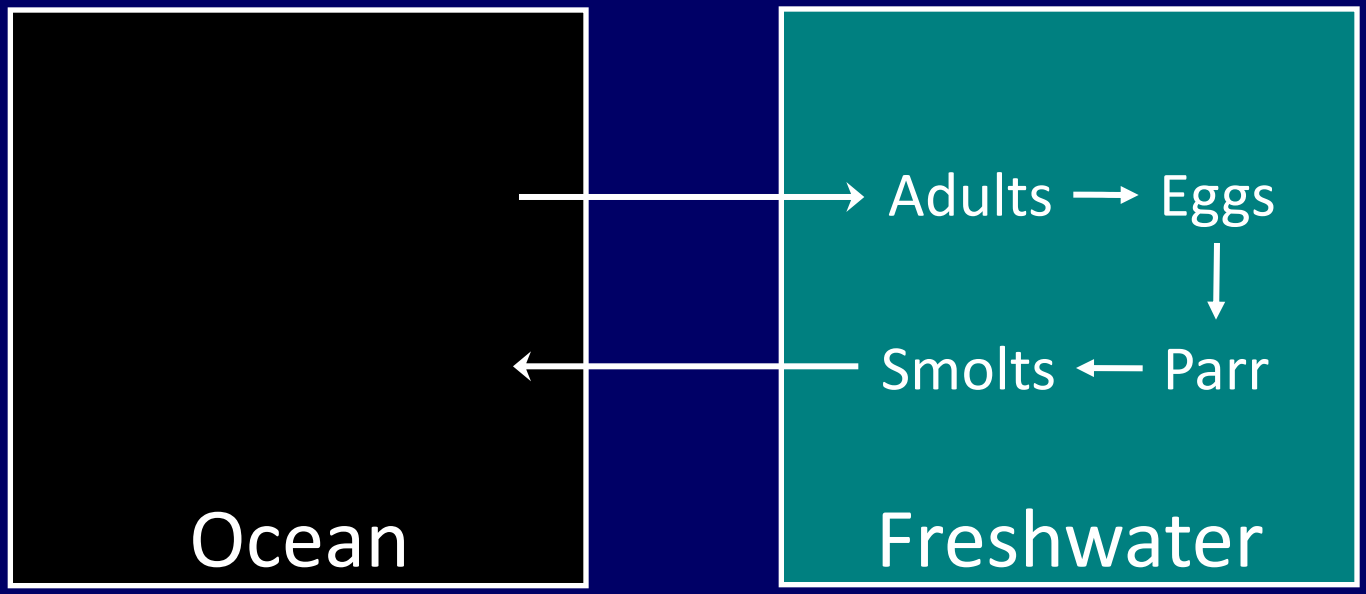
Muckelshoot Tribe

UW PRISM Project

Puget Sound
Technical Recovery Team

Snohomish Basin Salmonid
Recovery Technical Committee

An early view of the salmon life cycle



Wide range of impacts

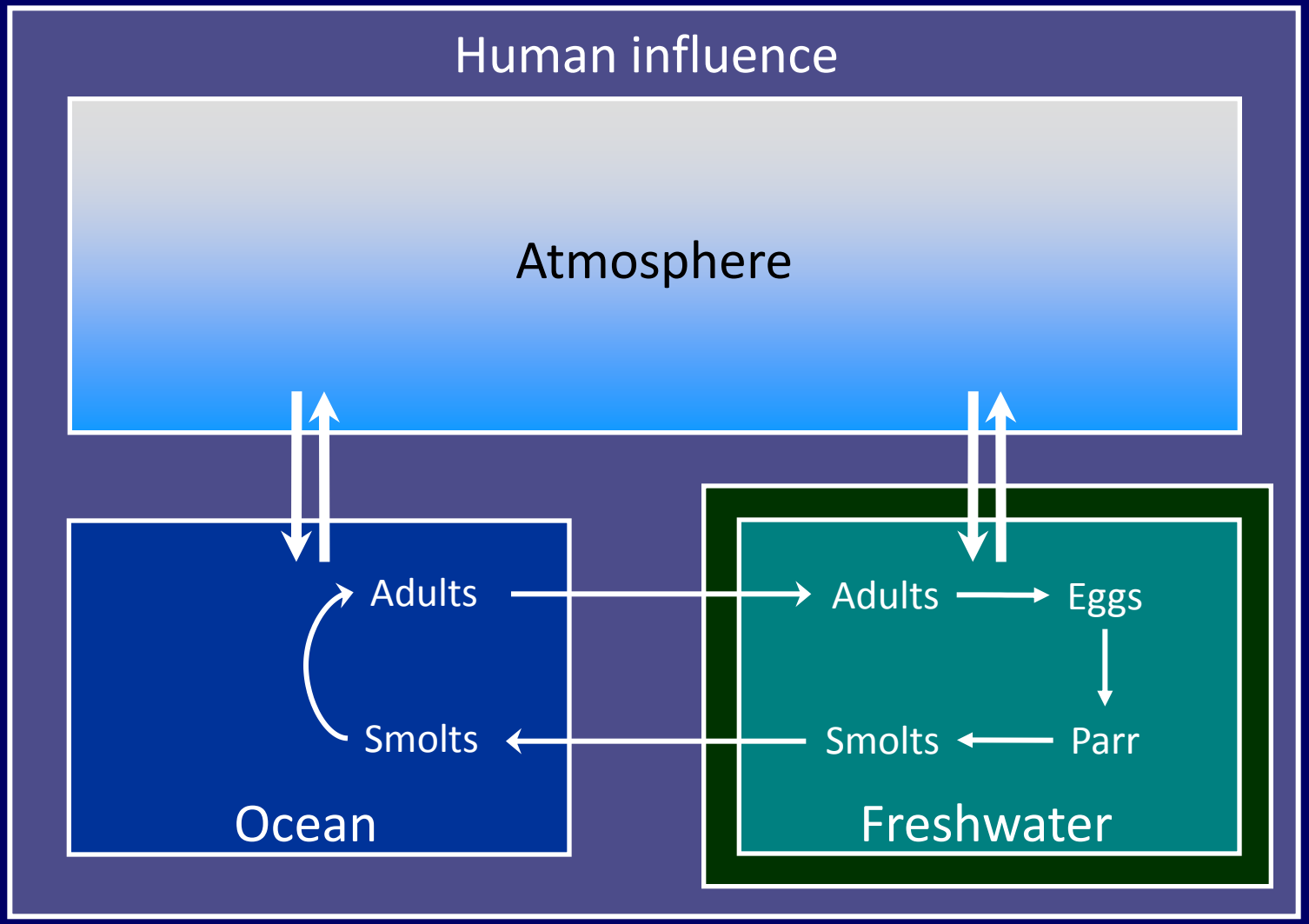

Exotic species


Climate change

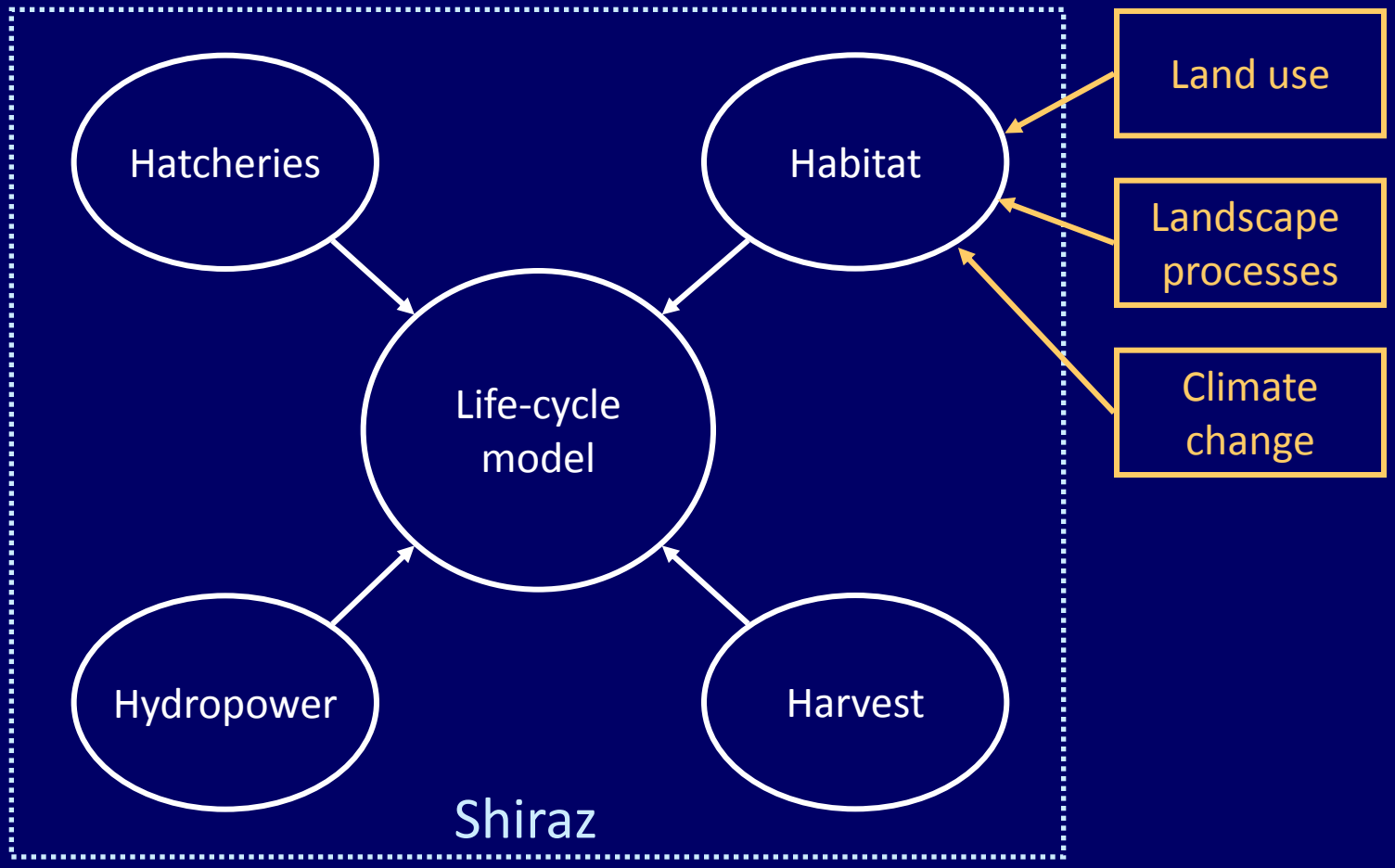

The 4 H's


Marine-derived resources

An expanded view



The Shiraz model framework



Scheuerell et al. (2006) *CJFAS*

Multistage Beverton-Holt model

(Moussalli & Hilborn 1986)

$$N_{s+1} = \frac{N_s}{\frac{1}{p} + \frac{1}{c} N_s}$$

N_s = individuals alive at life stage s

N_{s+1} = individuals alive at life stage $s + 1$

p = max. survival rate from s to s+1 (productivity)

c = max. N producible at s+1 (capacity)

Key model attributes

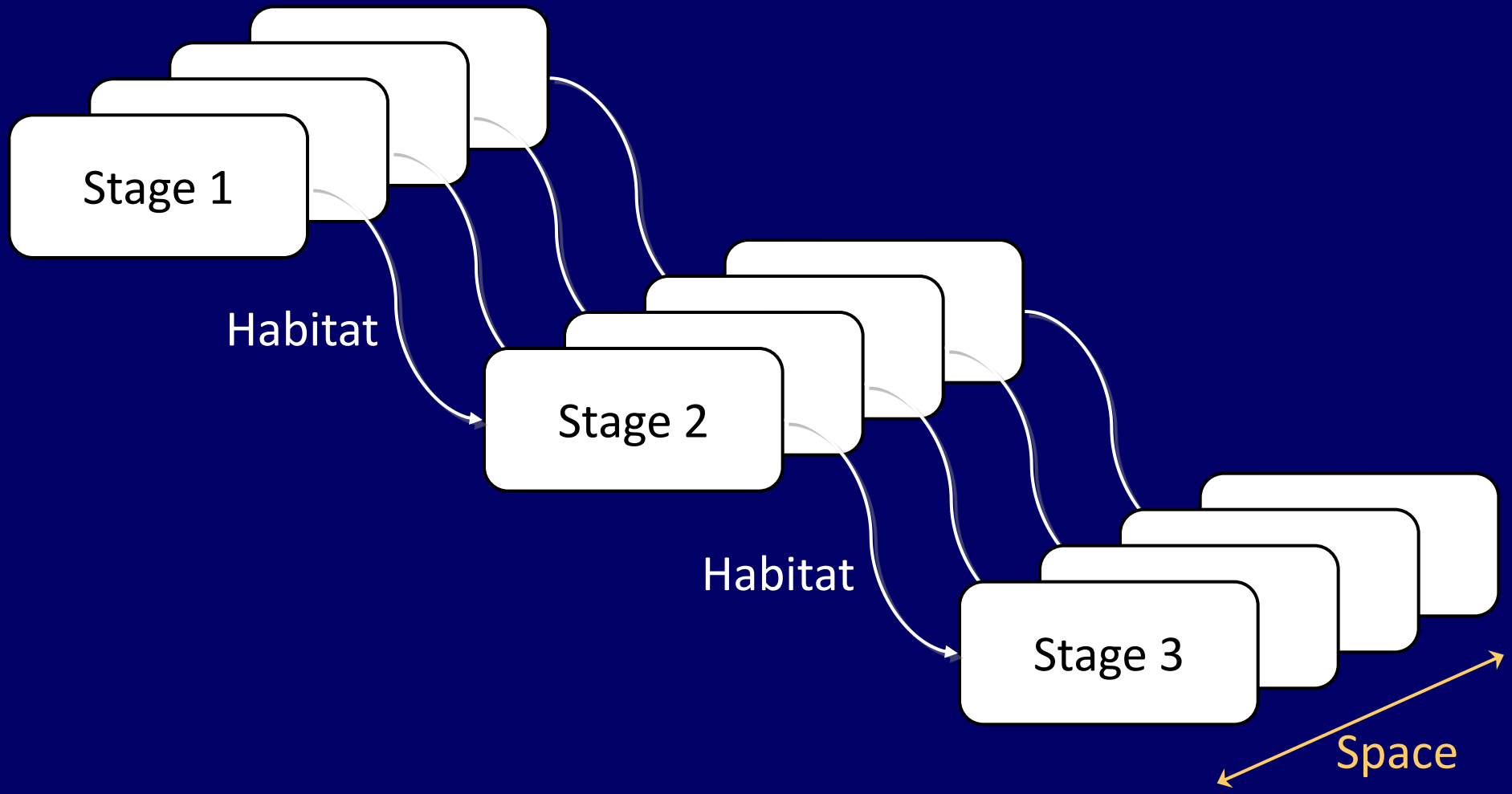
In general...

- Freshwater survival driven by the effects of habitat
- *c* determined by ***quantity*** of habitat
- *p* determined by ***quality*** of habitat

Also assume…

- Freshwater survival is ***density-dependent***
- Marine survival is ***density-independent***

Relate life history to habitat



Evaluating recovery strategies

- Snohomish River basin in Puget Sound selected for model test case

Evaluating recovery strategies

- Snohomish River basin in Puget Sound selected for model test case
- Contains 2 of 22 populations of Puget Sound Chinook listed as threatened under ESA

Evaluating recovery strategies

- Snohomish River basin in Puget Sound selected for model test case
- Contains 2 of 22 populations of Puget Sound Chinook listed as threatened under ESA
- Collaborative effort between scientists and policy makers

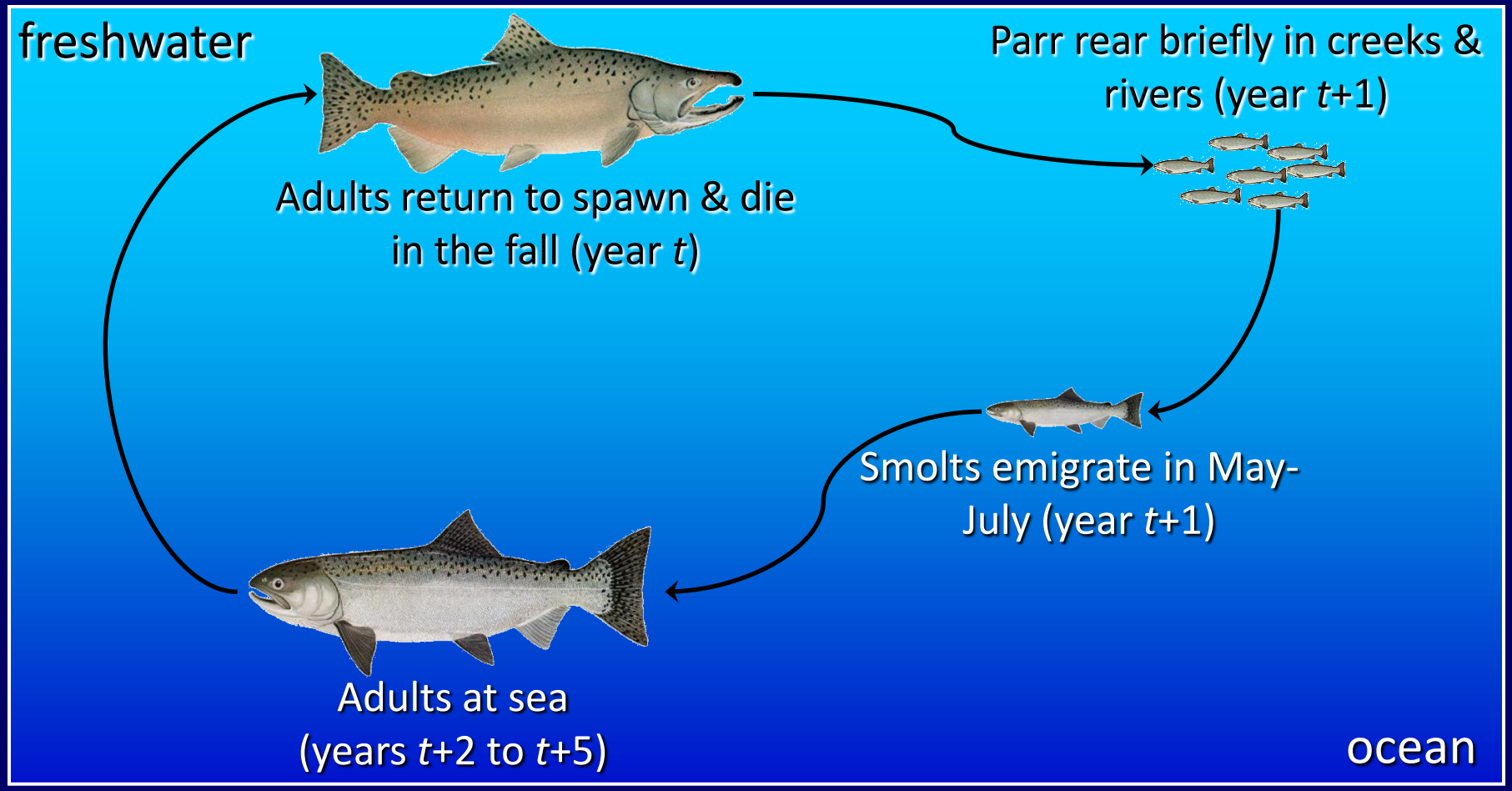
Evaluating recovery strategies

- Snohomish River basin in Puget Sound selected for model test case
- Contains 2 of 22 populations of Puget Sound Chinook listed as threatened under ESA
- Collaborative effort between scientists and policy makers
- Used “scenarios” to compare possible policy outcomes to current and historical conditions

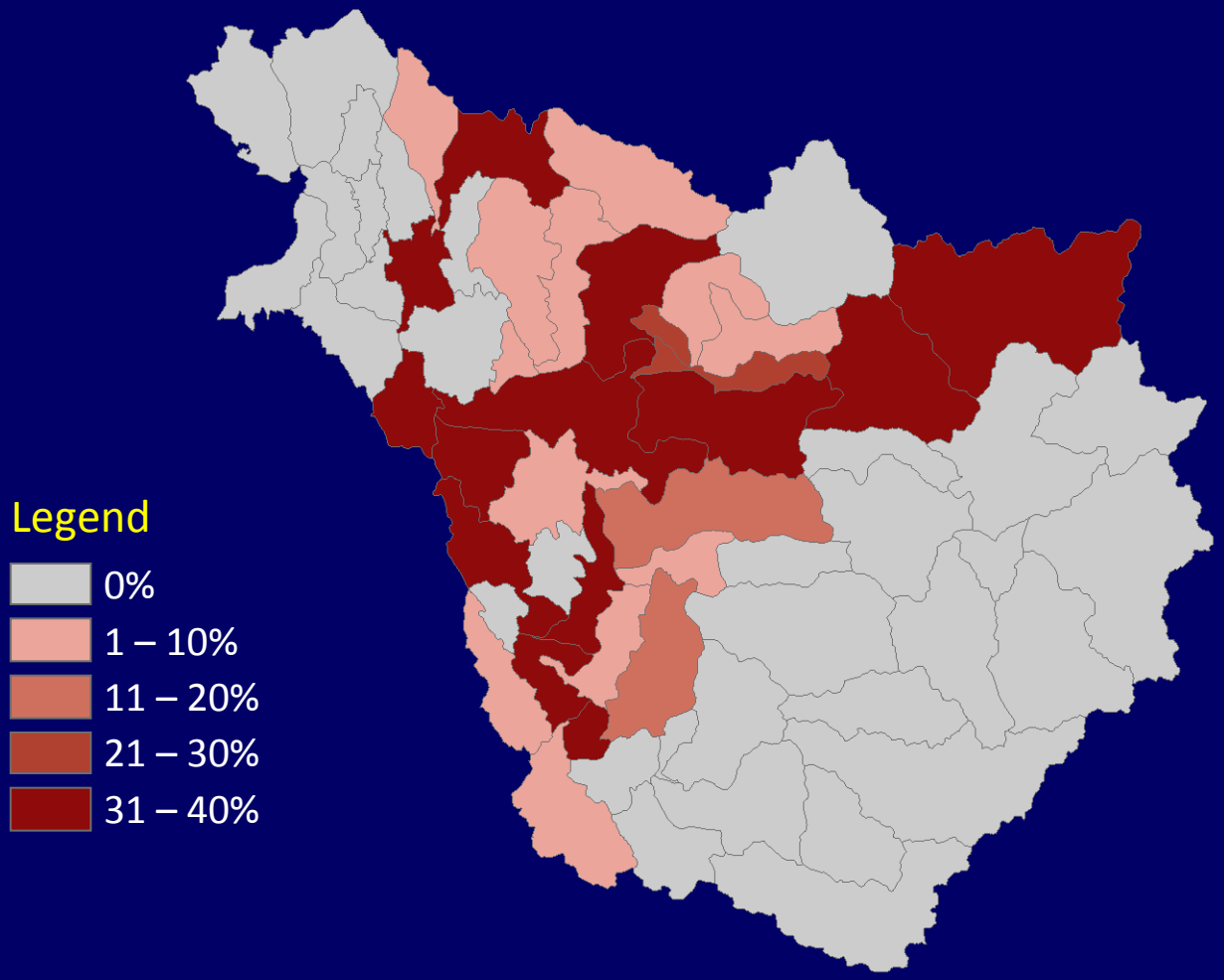
Snohomish River basin

Fall Chinook salmon

"Ocean type" life history

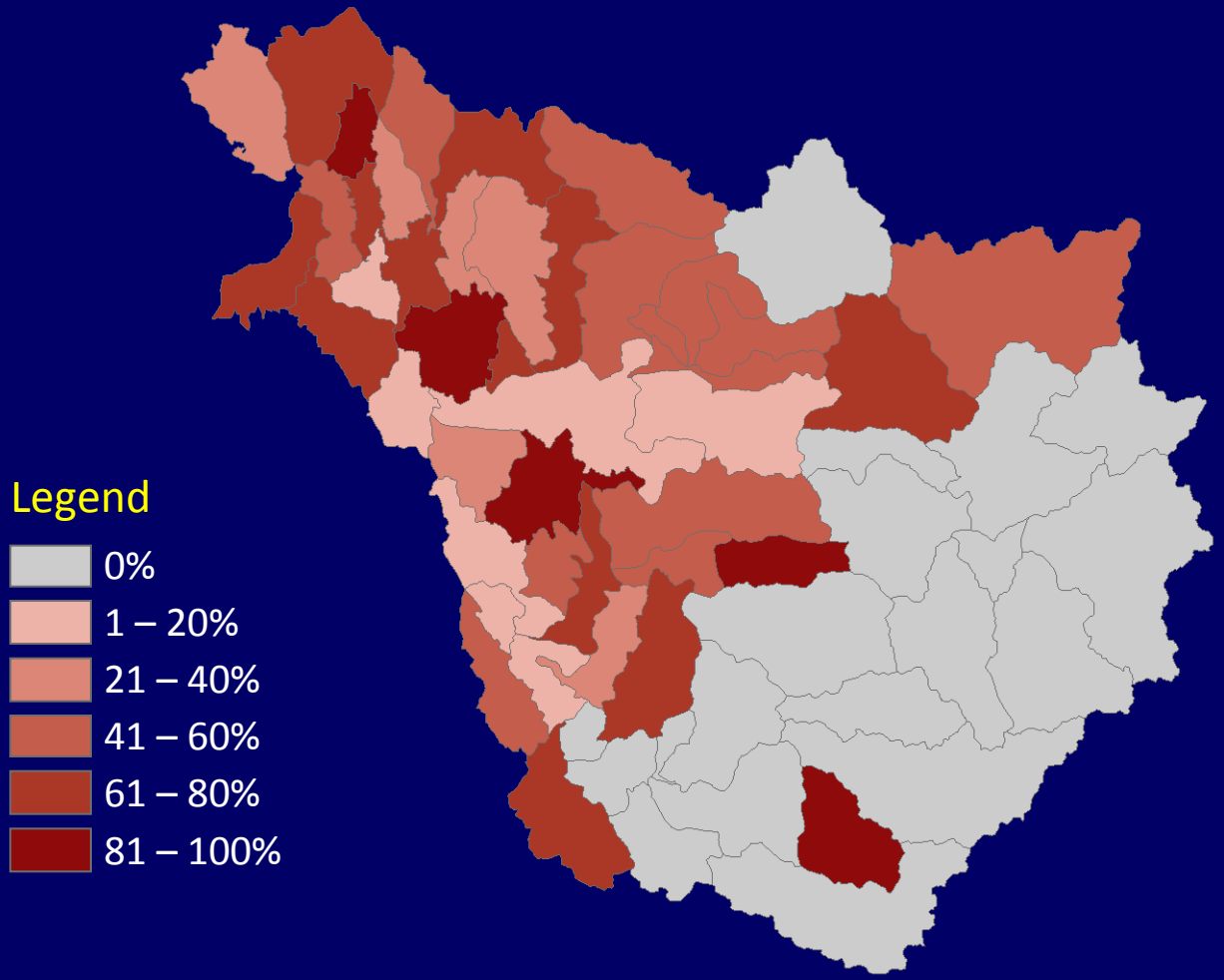


Reduction in spawner capacity



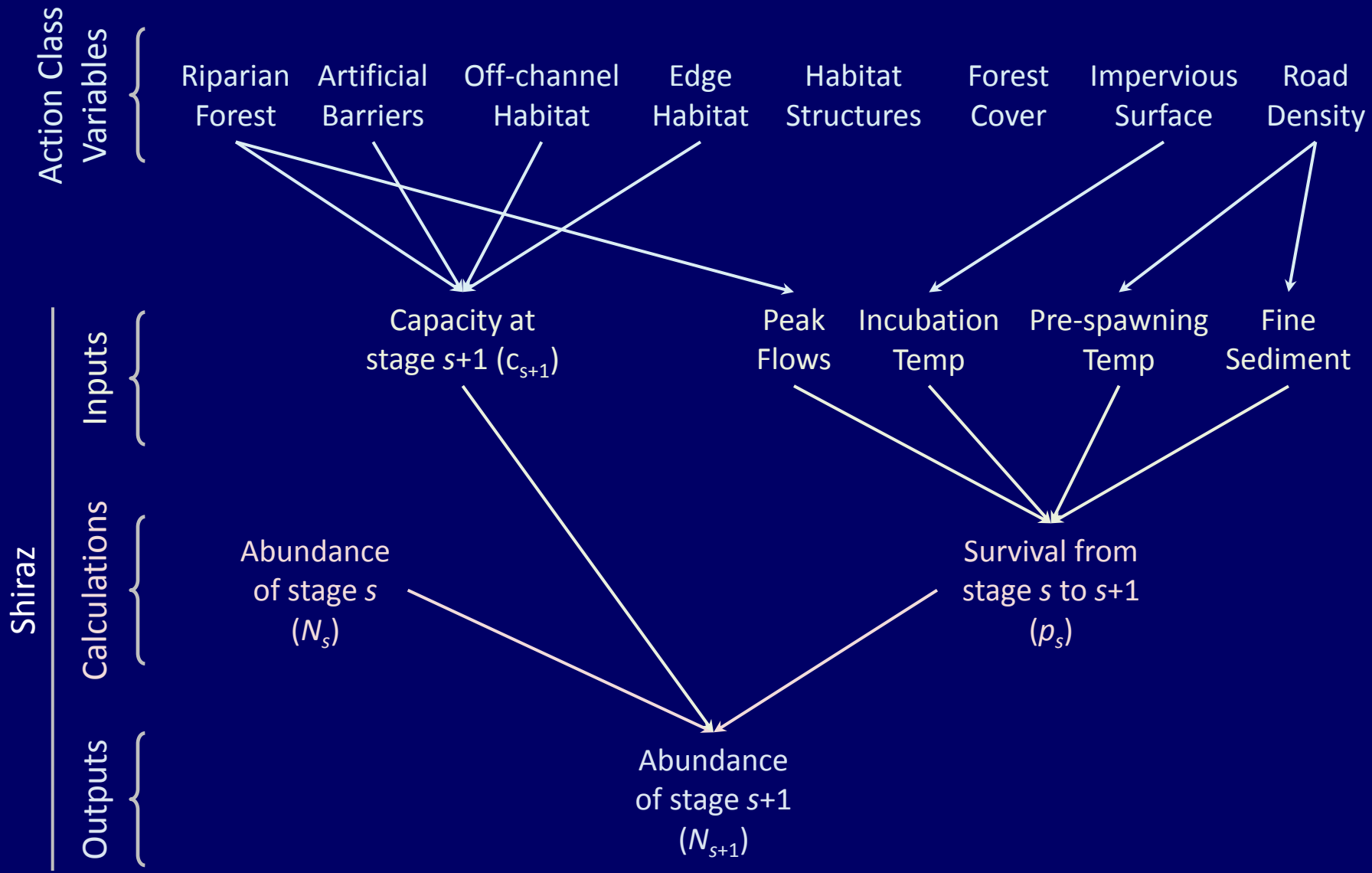
(Sanderson et al., NMFS, unpublished data)

Reduction in juvenile capacity



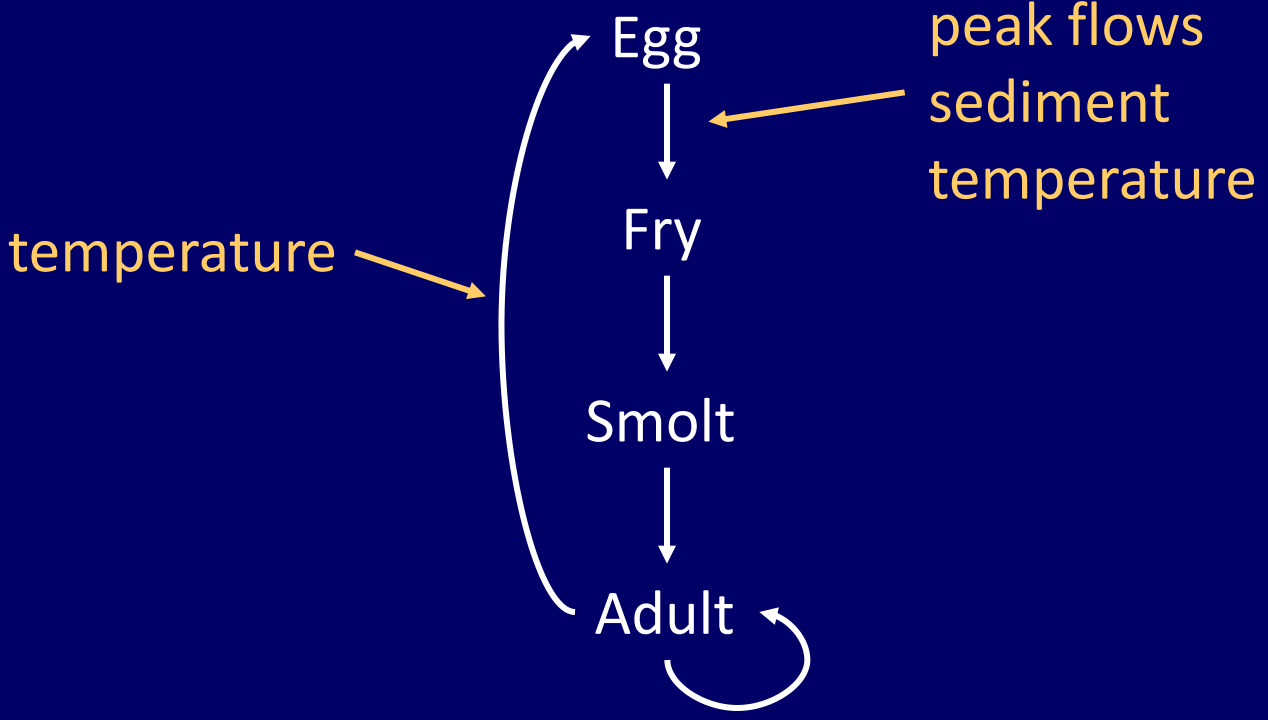
(Krista Bartz & Kerry Lagueux, NMFS, unpublished data)

Mechanistic model in Snohomish

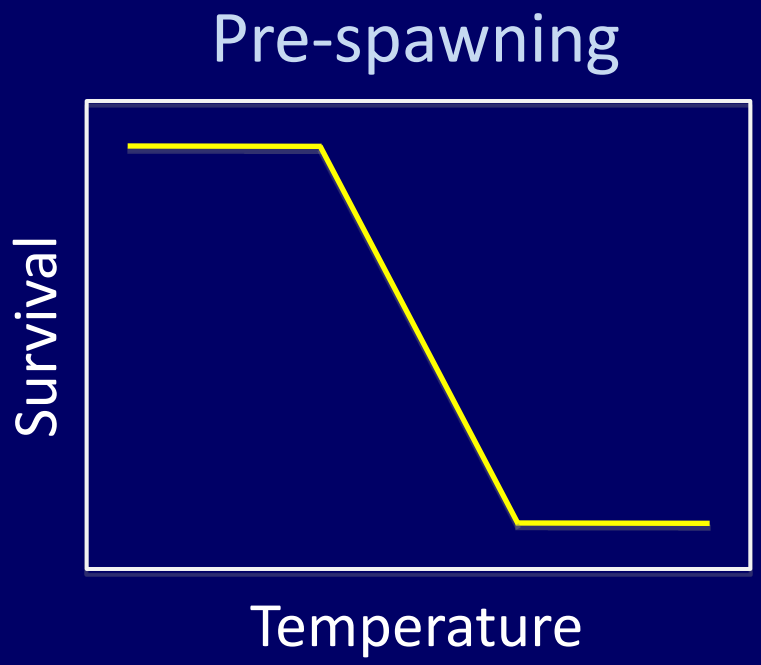


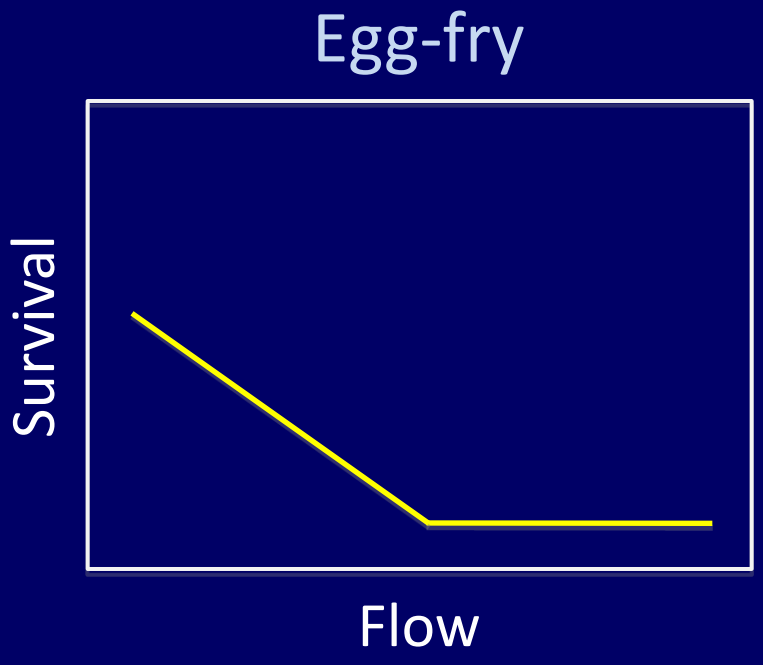
Putting the pieces together

For productivity…



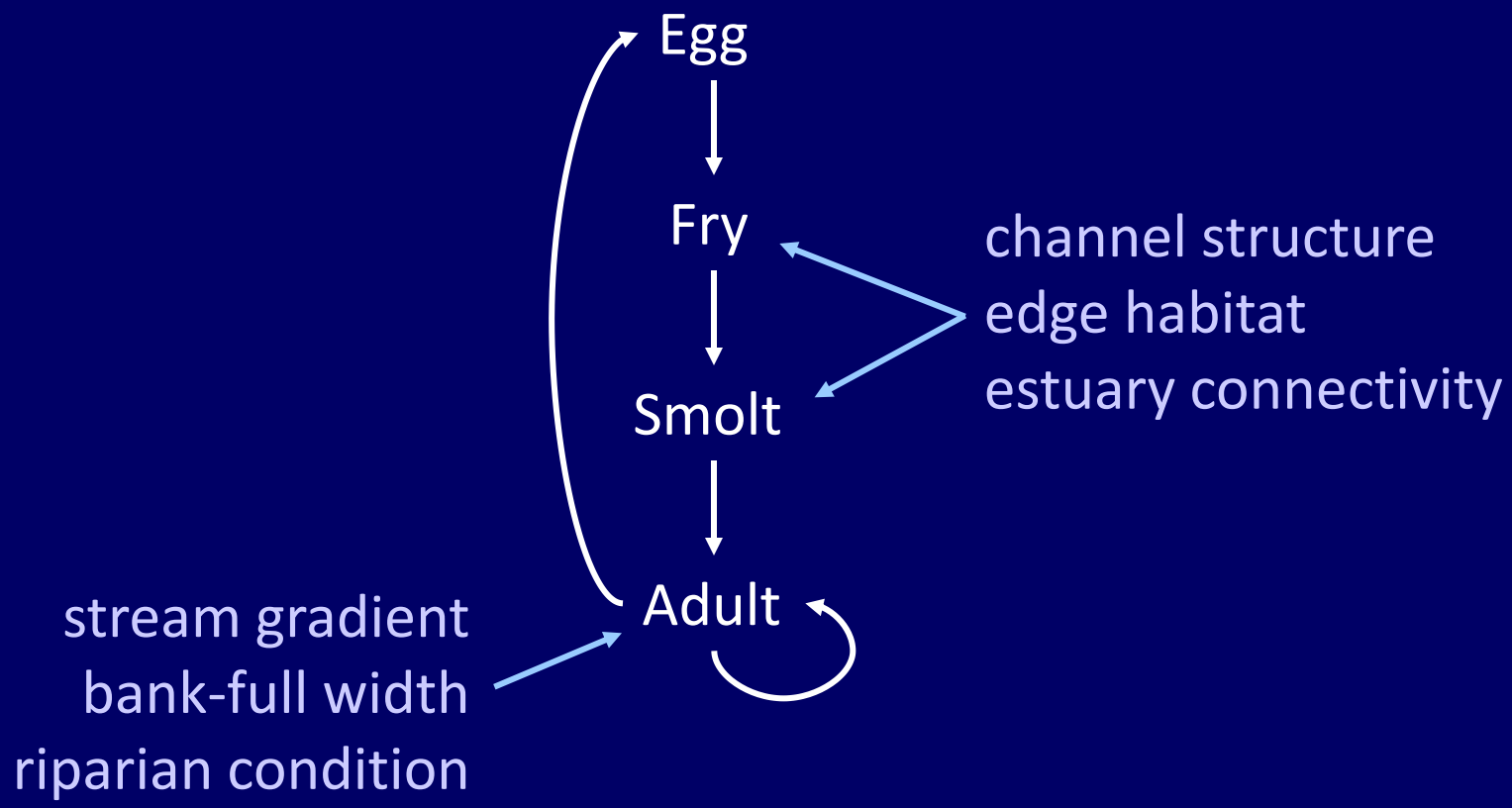
Some forms of relationships



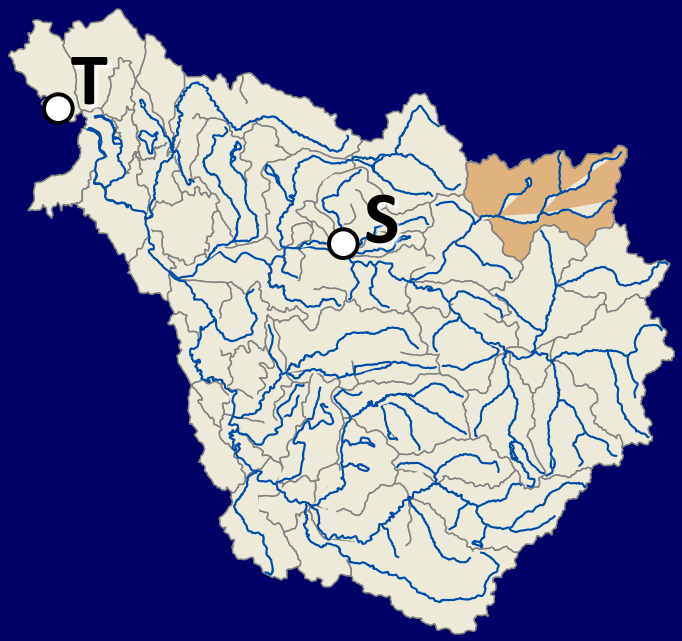


Putting the pieces together

For capacity…



Incorporating hatchery production



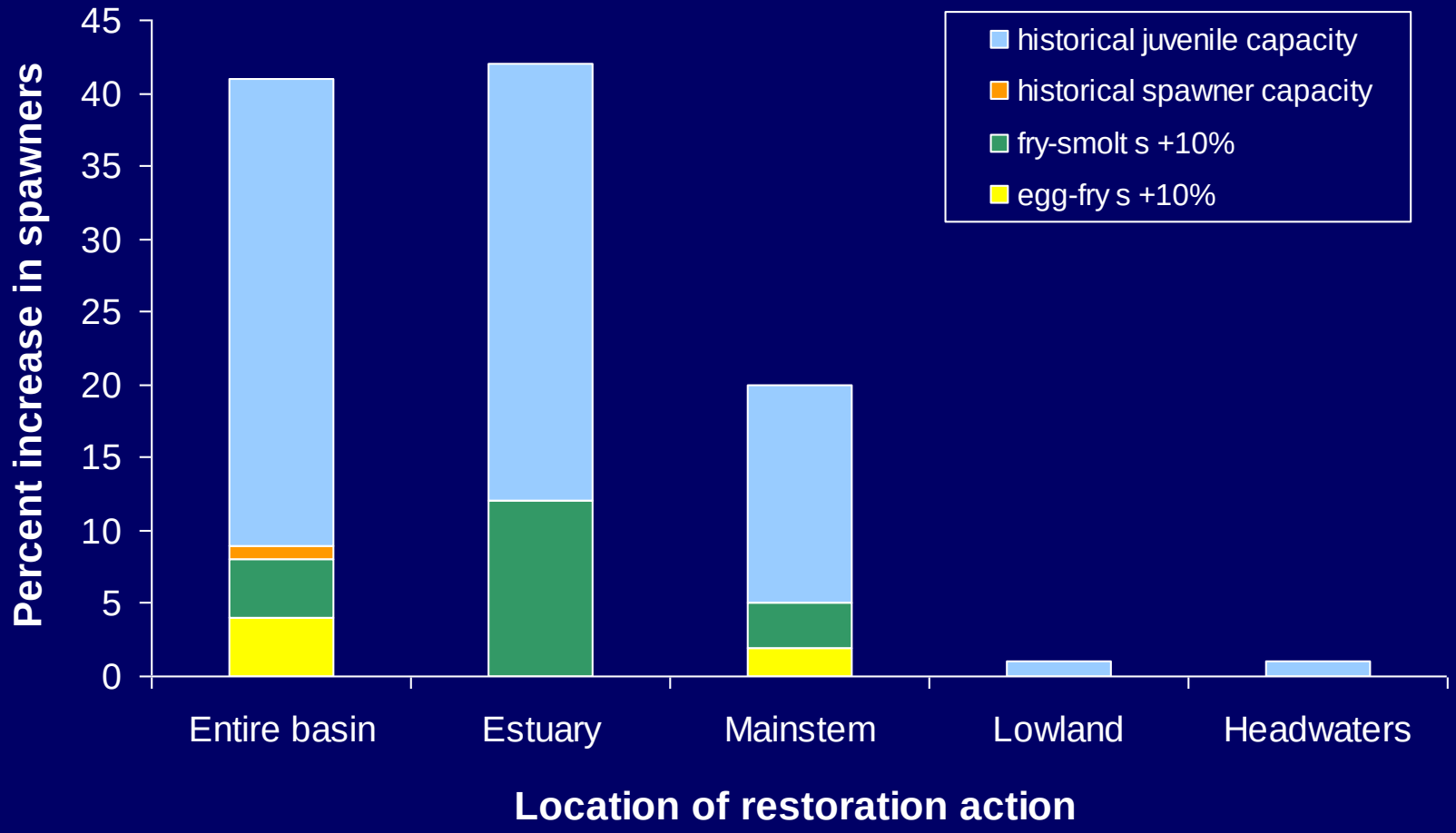
Hatchery	Stock	Life stage	Releases
Tribal	Summer	Fingerling	1,500,000
	Fall	Fingerling	200,000
State	Summer	Fingerling	1,000,000
	Summer	Yearling	250,000

Effects of harvest

Rebuilding exploitation rate (RER) = 24%

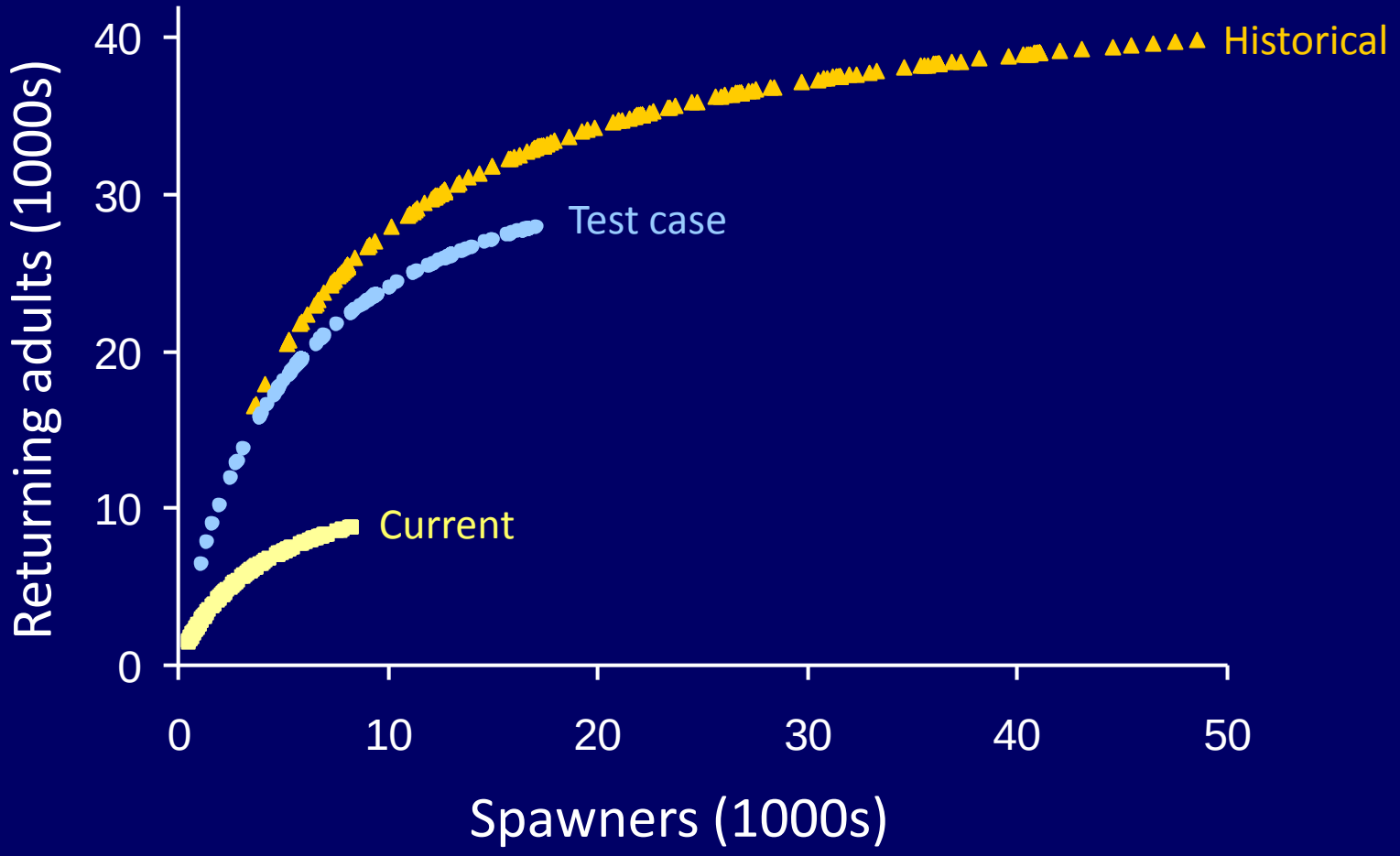
Actual ER = RER + ε $\varepsilon \sim N(0,0.2)$

Model sensitivity analyses



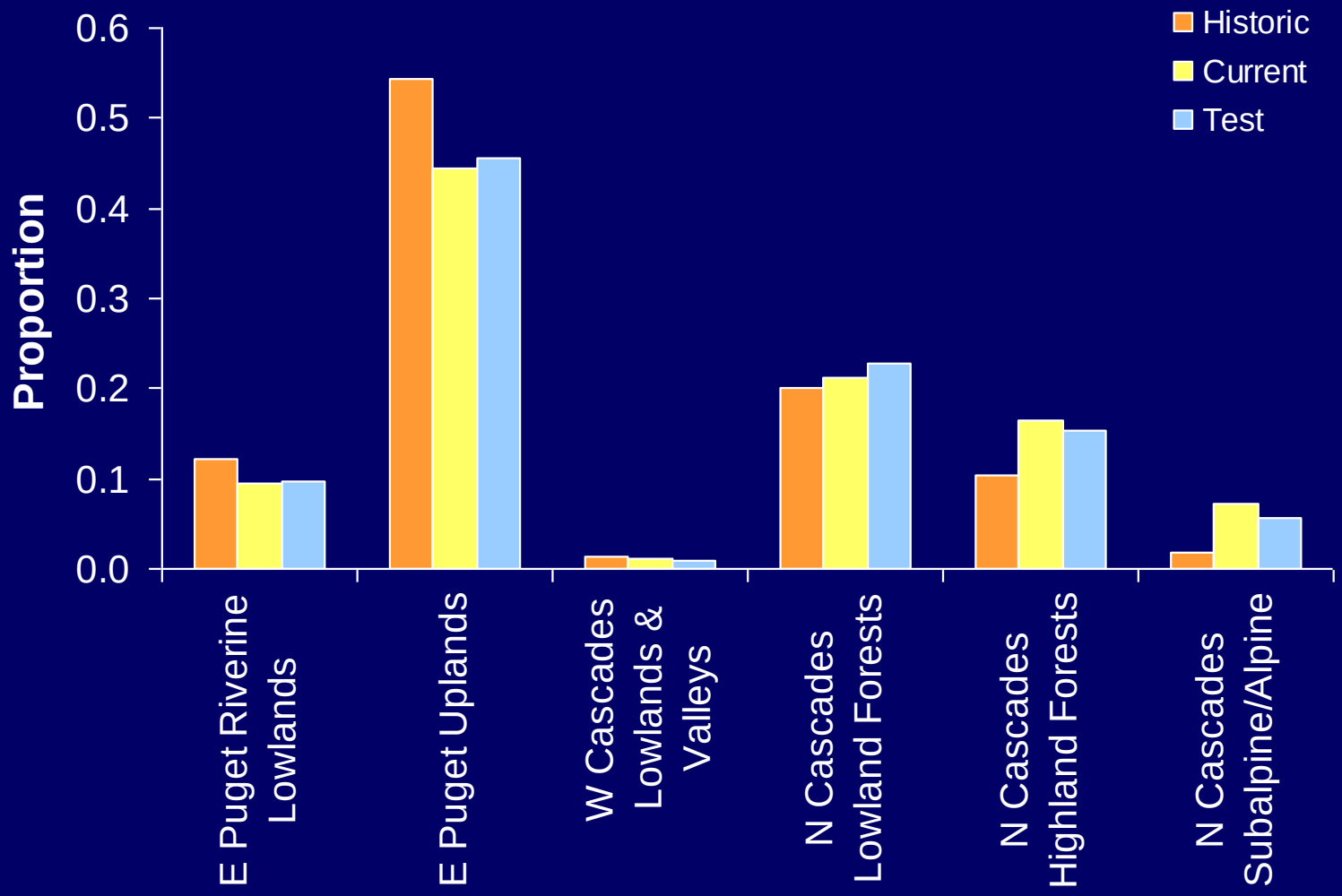
Scheuerell et al. (2006) *CJFAS*

Abundance & productivity



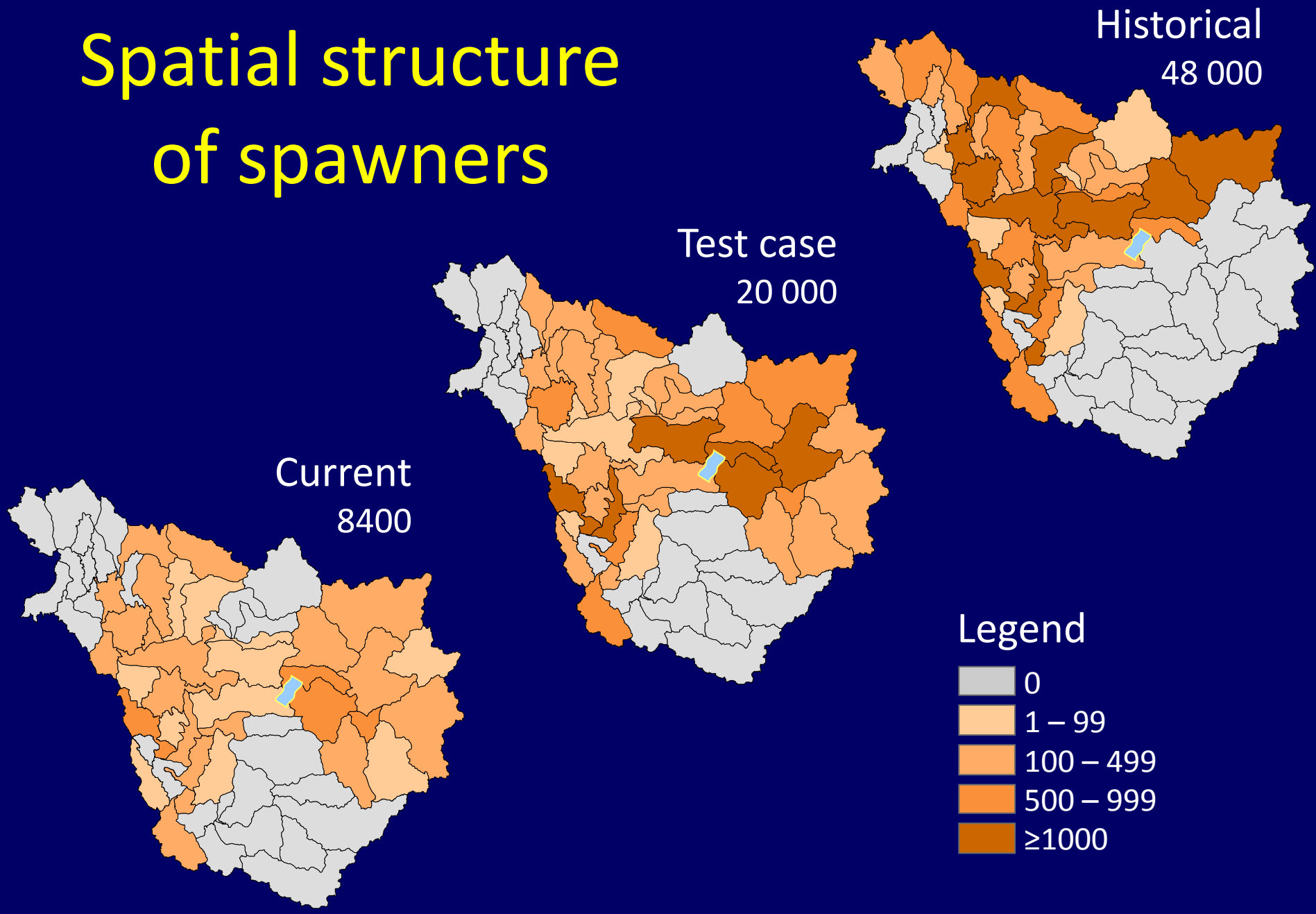
Scheuerell et al. (2006) *CJFAS*

Summarizing “diversity”



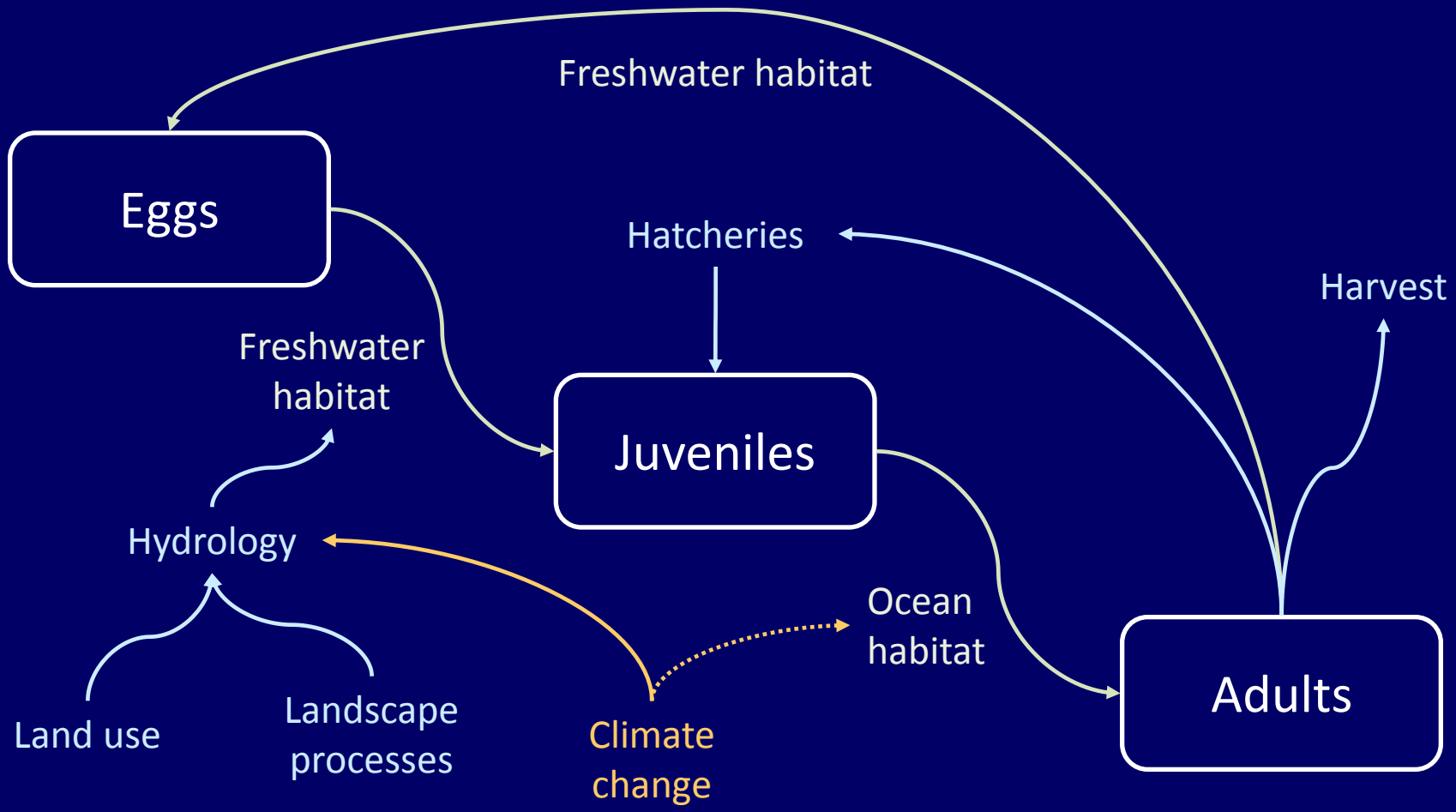
Scheuerell et al. (2006) *CJFAS*

Spatial structure of spawners



Scheuerell et al. (2006) *CJFAS*

The big picture



Modeling effects of climate change

2 Climate models

Input: predicted CO_2

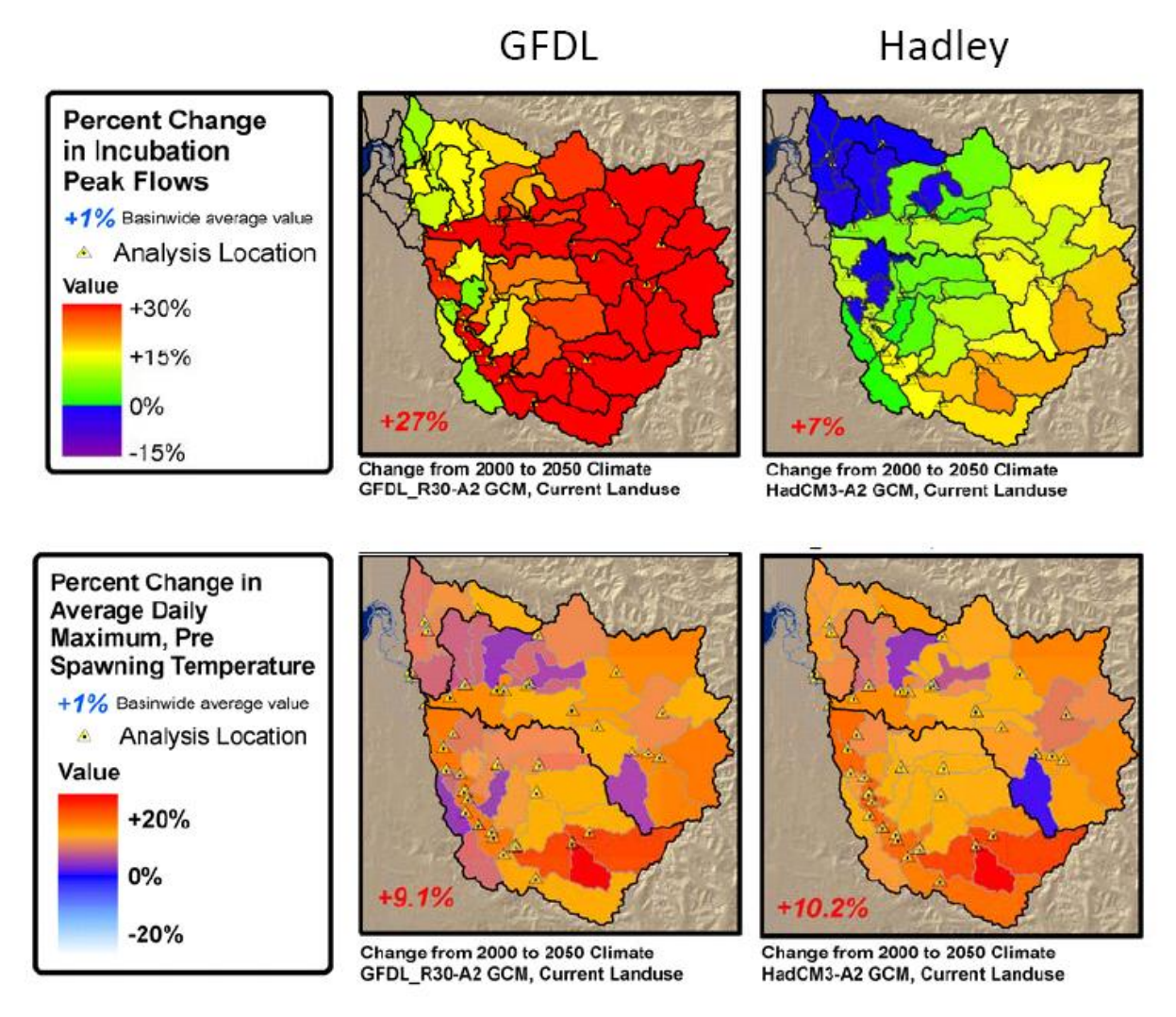
Output: air temperature
meteorology

Hydrology model

Input: land cover
land form
air temperature
meteorology

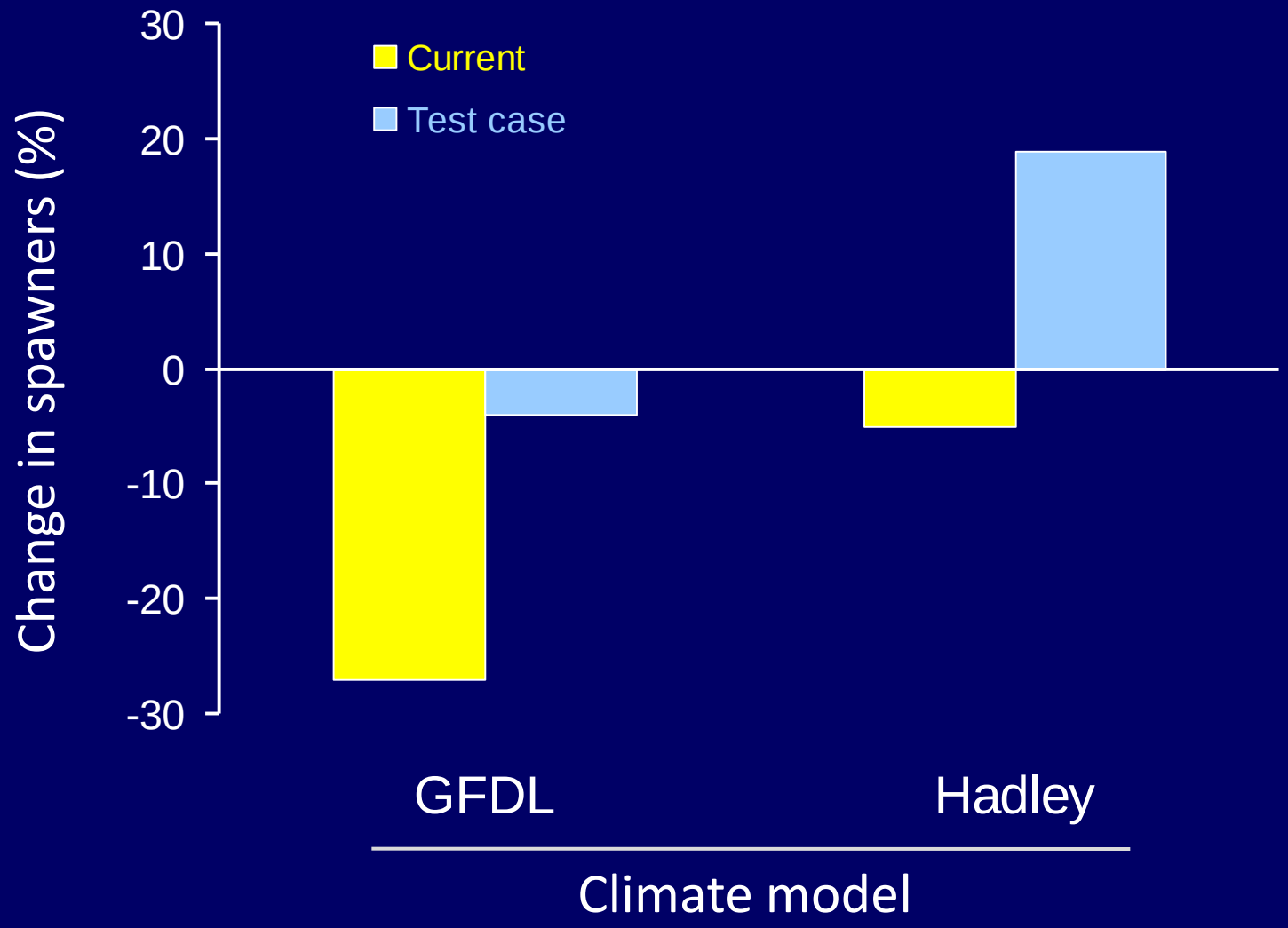
Output: stream flow
stream temp

Effects of climate change



Battin et al. (2007) *PNAS*

Climate effects in 50 years



Battin et al. (2007) *PNAS*

Other applications of Shiraz

- Climate effects on restoration scenarios
  - Battin et al. (2007) *Proc. Natl. Acad. Sci*
- Essential Fish Habitat for salmon
  - Scheuerell & Hilborn (2009) *Am. Fish. Soc. Symp.*
- Spring Chinook in upper Columbia
  - Honea et al. (2009) *Freshwater Biology*
  - Jorgensen et al. (2009) *Freshwater Biology*

Shiraz limitations

- Not presently available in public domain due to legal restrictions

Shiraz limitations

- Not presently available in public domain due to legal restrictions
- Not very “user friendly” – requires specific knowledge

Shiraz summary

- It’s a transparent modeling framework

Shiraz summary

- It’s a transparent modeling framework
- Uses flexible life history

Shiraz summary

- It’s a transparent modeling framework
- Uses flexible life history
- Spatially explicit habitat characteristics

Shiraz summary

- It’s a transparent modeling framework
- Uses flexible life history
- Spatially explicit habitat characteristics
- Offers information on VSP criteria

Shiraz summary

- It’s a transparent modeling framework
- Uses flexible life history
- Spatially explicit habitat characteristics
- Offers information on VSP criteria
- Structure can be simplified or expanded